

VISIT...

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# BRAINS AND MACHINES

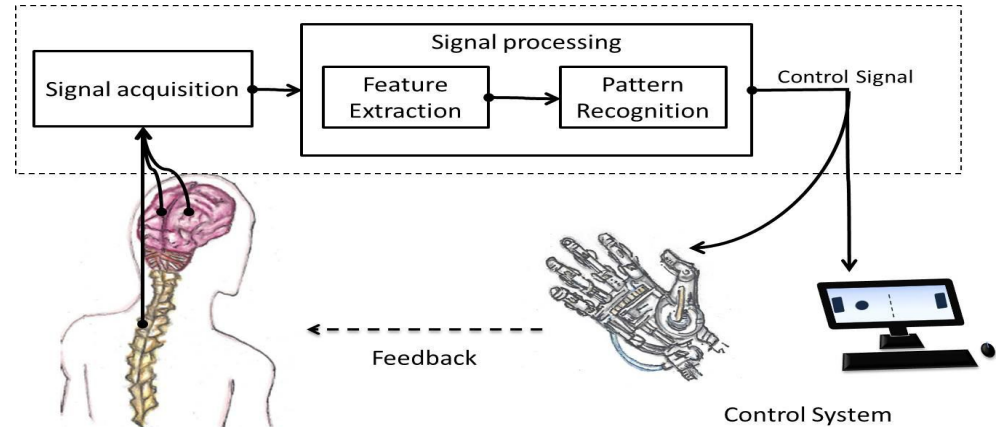
**Lesson 5, Psychology week 3 REACH**

# IN THIS LESSON

1. Brain computer interface - what is this?
2. Cochlear implant
3. Brief history and Transhumanism
4. Sensory BCIs (1 h)
5. Cognitive enhancements (1 h - discussion)

# BCI - WHAT ARE THEY?

- ‘A brain-computer interface is a communication system that does not depend on the brain’s normal output pathways of peripheral nerves and muscles.’
- Usually devised to fix an impairment
- **Basic principle:** a mechanical structure takes over the functions of a damaged organ, brain part.



# BCI - WHAT ARE THE USES?



Split in twos - write down as many as you can

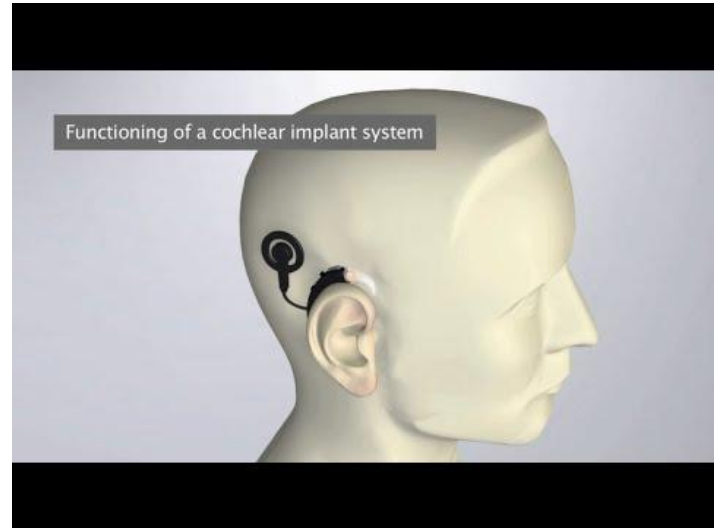
# COCHLEAR IMPLANT

- If you damaged your ear
  - Or are born with a hearing impairment
  - Most likely the auditory nerve is OK
  - But the hair cells in BM are diminished.
  - So you can't transform the signal into different Hz (filter it) and activate different parts of the auditory nerve
  - Which will then transfer different parts of sounds to the Auditory Cortex
- 
- Cochlear implant is a simple BCI



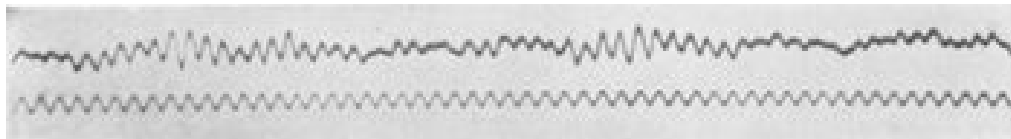
# COCHLEAR IMPLANT - HOW DOES IT WORK?

- Bypasses the inner ear
- Has two parts - speech processor placed over the ear
- Receiver - stimulator implanted under the skin
- The processor breaks down the sound into sound waves of different frequencies
- The stimulator sends each wave into corresponding section of the electrodes
- Electrodes are placed over the correct sections of the membrane
- Stimulate the cells under the membrane
- Signals are then transferred info to the auditory nerve



# BCI HISTORY

- **1924** : Hans Berger discovers the electrical activity of the human brain with EEG



- **1976**: UCLA's Brain Computer Interface Laboratory visually **evoked potentials** that could be used to control a cursor through a two-dimensional maze.
- **1999**: BCI is used to aid a quadriplegic for limited hand movement
- **2000+** - lots of developments, including human-to-human interface, complex motion control, BCI prosthesis



# TRANSHUMANISM

Most of the BNIs are aimed at restoring to human condition (fixing), but some are aimed at improving the human condition.

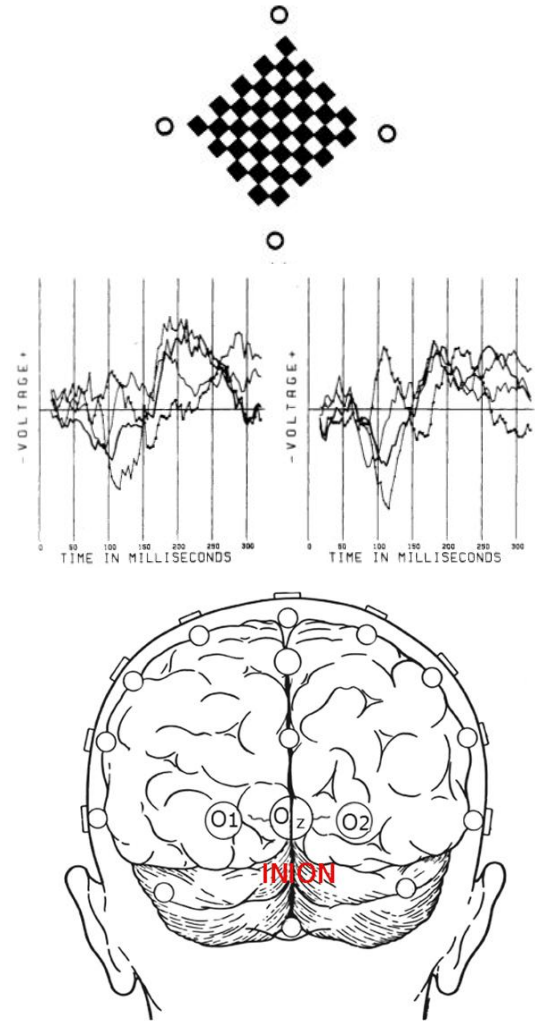
The idea of **Transhumanism**

creating widely available sophisticated technologies to greatly enhance human intellectual, physical, and psychological capacities



# CONTROLLING CURSORS WITH ELECTRODES

- Several electrodes are placed on the visual cortex to collect ERPs
- Subject is asked to focus on one of the 4 locations
- The signal from each trial pre-processed, smoothed but not averaged!
- Averaging doesn't work if we want to control things in real time
- An algorithm was implemented on the ERPs
- It classified, based at the relative strengths and distributions of ERPs, which dot the subject is looking at.
- Based on the classification the computer could move the cursor.



# DEMONSTRATION



# EXPLAIN IN DETAIL WHAT IS HAPPENING

Volunteer!

# BCI - HOW IT WORKS (COMPONENTS)

- **Input** - chosen EEG features recorded inside or outside of the skull
- **Classification algorithm** - a computer decides which of several ERPs represents the target (linear or nonlinear equations, a neural network, or other methods)
- **Output** controls signals. BCI outputs can be cursor movement, letter or icon selection or another form of device control.
- **And some key problems:** matching the classification algorithm to the user - everyone's brain activity is somewhat different.



# SENSORY BCIS - TYPES

Invasive

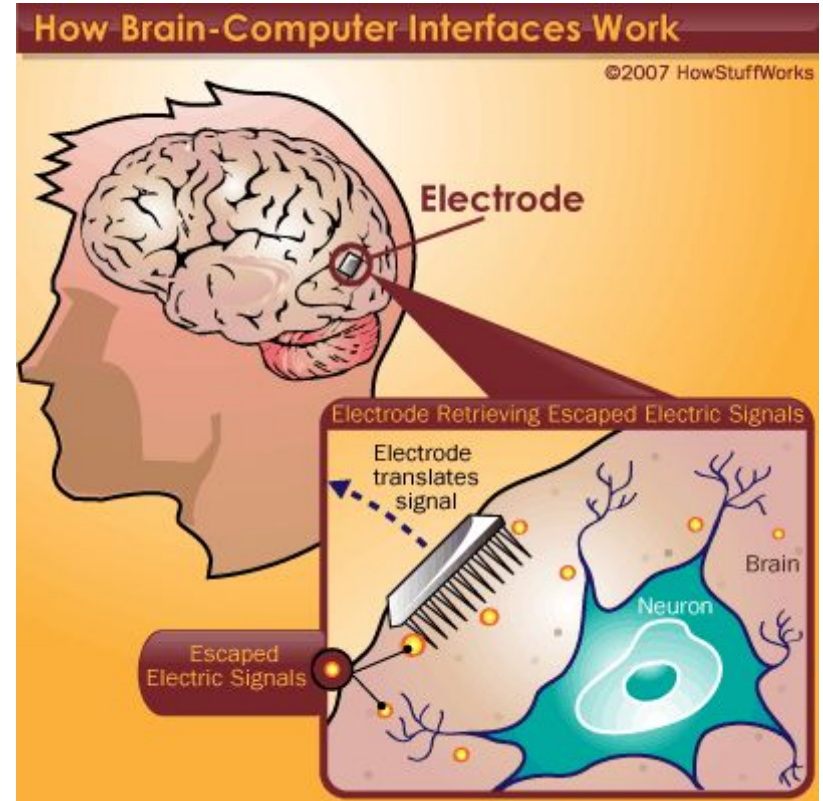
Non-invasive

Partially invasive

Most are aimed at restoring damaged hearing, sight and movement

# INVASIVE BCIs

- Implanted onto the cortex
- Used to provide functionality to paralyzed people
- Restore vision by connecting the brain with external cameras
- Restore the limb control by using brain controlled robotic arms and legs
- Problems: prone to scar-tissue buildup



# VISION CONTROL





# LIMB CONTROL



# CONCLUSIONS SO FAR

BCIs have been successfully implemented for the sensory systems.

Why do you think this is the case?

What did I tell you about the sensory systems?

# NON-INVASIVE BCIS

- Mostly EEG ERPs
- Humans are asked to imagine simple actions
- These are translated to a code readable by a machine
- Can be used for medical and nonmedical purposes
- Examples: gaming

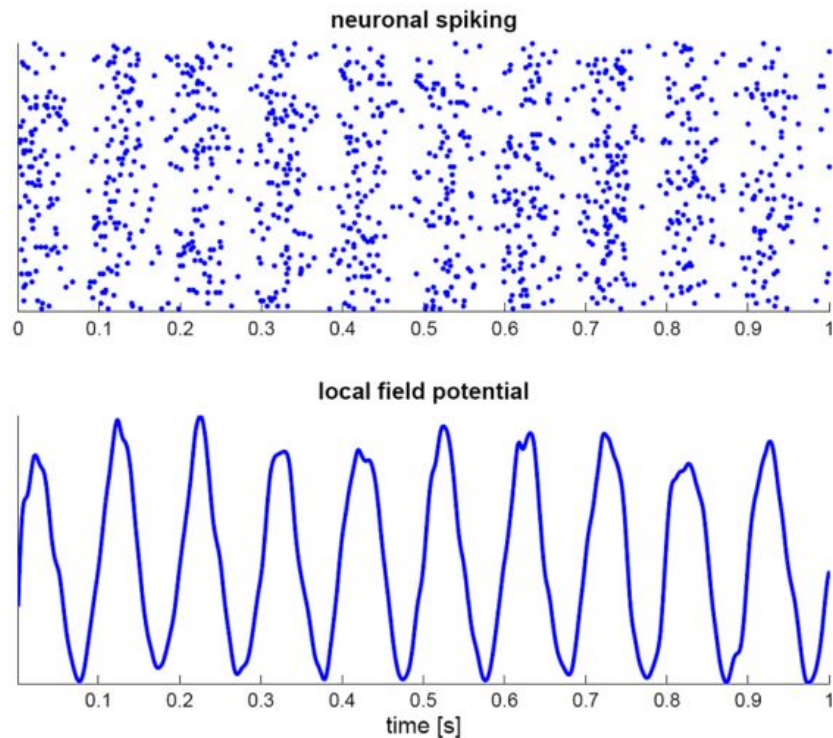


# TOY CONTROL



# DIFFERENT WAYS TO ENCODE BCIS (NEURAL OSCILLATIONS)

- Oscillatory activation of postsynaptic neurons
- Many neurons fire together with specific frequencies
- This is thought to be used to transfer information from one part of the brain to the other
- Feature binding, information transfer mechanisms and the generation of rhythmic motor output



# NEURAL OSCILLATIONS TYPES

- Alpha 7-12 Hz

When eyes are closed, areas of the cortex not in use are inhibited

- Beta 12-30 Hz

Active reasoning, resource-consuming tasks

- Gamma 25-100 Hz

May be implicated in creating the unity of conscious perception?

# DEMONSTRATION



# PARTIALLY INVASIVE BCIs

- implanted inside the skull but rest outside the brain
- Better resolution than non-invasive BCIs, as the skull shields the signals
- Electrocorticography electrodes that are placed in a thin plastic pad, placed above the cortex
- In 2004 researchers enabled a teenage boy to play Space Invaders using his ECoG implant





# QUESTION TIME

List limitations of this technology?

What we can and cannot do?

# SURVEYS - PLEASE COMPLETE BOTH - 30 MIN

<https://www.surveymonkey.co.uk/r/ReachGeneralProg2016>

and a subject-specific one, the link for which is: <https://www.surveymonkey.co.uk/r/ReachPsychJuly2016>

Note for me - equipment needs to be returned to the Reach office (the projector and speakers and their cables and the extension lead)